Optimization of Supersonic Jet Noise Using a Reynolds-Averaged Navier-Stokes Approach, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

The objective of this proposal is the development and demonstration of a cost-effective high-fidelity aeroacoustic design tool for future commercial supersonic nozzle designs and installations. Although eddy-resolving CFD methods for computing high-speed jet noise are available, such methods are computationally expensive and are currently deemed impractical for use in a design optimization loop. On the other hand, the prediction of turbulence generated noise using the RANS equations provides a less accurate but more cost-effective approach for practical design problems, wherein the turbulence length and time scales needed to model the local noise source terms can be extracted from the RANS turbulence model solution, as performed by the NASA JeNo code. In this Phase 1 proposal, we seek to demonstrate the feasibility of using the exact discrete adjoint of a coupled RANS-JeNo turbulent noise prediction methodology for optimizing far-field acoustic objectives of jet noise. Based on our previous experience developing an unsteady RANS-FWH (Ffowcs Williams-Hawkings) far-field acoustic optimization capability, the Phase 1 proposal targets the formulation of the turbulence noise source terms used by the JeNo code, along with the discrete adjoint of these terms within an existing adjoint-enabled RANS solver. The immediate goal will be to demonstrate the possibility of reducing these noise sources through nozzle shape optimization. In Phase 2, this capability will be linked with the NASA JeNo code, and the remaining terms for the formulation of the discrete adjoint of the coupled RANS-JeNo simulation capability will be implemented and used to perform optimization of far-field noise signatures for realistic nozzle configurations. By targeting the specific terms that drive the noise propagation in the JeNo formulation, our Phase 1 approach will demonstrate the feasibility of using a fully coupled RANS-JeNo code for cost-effective gradient-based jet noise optimization.

Anticipated Benefits

The proposed technique will provide a novel tool for enabling the design of supersonic nozzles optimized for reduced far-field noise signatures. This is an important application area for NASA ARMD, since the acceptance of future commercial supersonic aircraft depends heavily on reduced environmental impact. The optimization approach will be developed in a modular fashion and will be easily transferable to NASA in-house RANS codes which incorporate an adjoint capability such as FUN3D.

The jet noise optimization capability will be incorporated into the simulation and design tools developed by Scientific-Simulations LLC and will be marketed to existing and potential new customers. The proposed approach is seen as a natural extension of the various multidisciplinary adjoint capabilities already developed at Scientific Simulations, and will enable new applications in high-speed jet noise optimization, which may be introduced in combination with these other disciplines.

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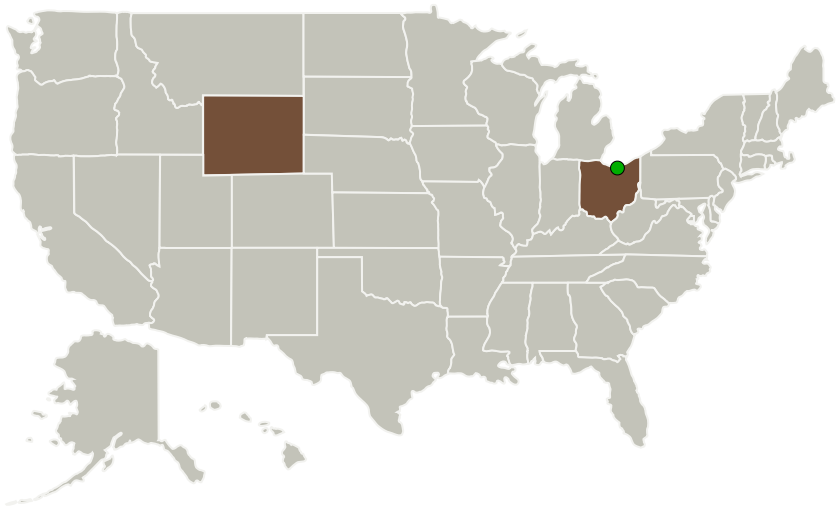
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Scientific Simulations LLC	Lead Organization	Industry	Laramie, Wyoming
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations	
Ohio	Wyoming

Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141222)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Scientific Simulations LLC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

Zhi Yang

Co-Investigator:

Zhi Yang

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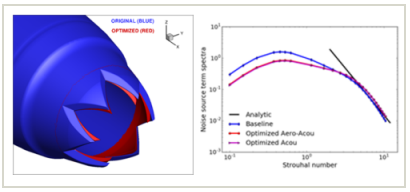
Images

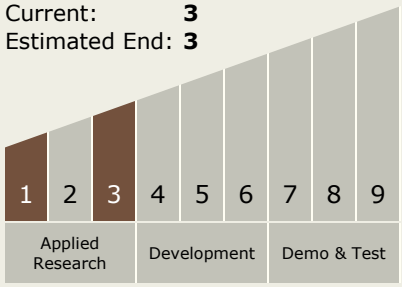
Briefing Chart Image
Optimization of Supersonic Jet Noise Using a Reynolds-Averaged Navier-Stokes Approach, Phase I *(https://techport.nasa.gov/image/135334)*



Final Summary Chart Image
Optimization of Supersonic Jet Noise Using a Reynolds-Averaged Navier-Stokes Approach, Phase I *(https://techport.nasa.gov/image/135367)*

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX15 Flight Vehicle Systems
  - TX15.1 Aerosciences
    - TX15.1.4 Aeroacoustics

Target Destination

Earth